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SYSTEM SPECIFICATION FOR THE REUSABLE REENTRY SATELLITE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Contract NAS9-18202
DRL 04

Prepared by
Science Applications International Corporation

Prepared for
Lyndon B. Johnson Space Center

SAIC RRS-038

An Employee-Owned Company

21151 Western Avenue
Torrance, California 90501

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FIGURES

1.0 SCOPE

This specification establishes the performance, design, development, and test requirements for the Reusable Reentry Satellite (RRS) system.

2.0 APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

2.1 GOVERNMENT

T0-00-25-203 01 Dec 1972 Change 11 02 Mar 1985	Contamination Control of Aerospace Facilities, U.S. Air Force
MIL-HDBX-5E 01 Jun 1987	Metallic Materials and Elements for Aerospace Vehicle Structures

7 U.S.C. 2131 et seq Animal Welfare Act of 1966, as amended

MIL-HDBK-17A 08 Jun 1977	Plastics for Flight Vehicles
MSC-SPEC-C-20A 16 Apr 1986	Manned Spacecraft Center Specification for Water, High Purity
NASA SP-R-0022A 09 Sep 1974	General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application

MIL-HDBK-23A 30 Dec 1968 Notice 1 09 Mar 1972 Notice 2 24 Apr 1974 Notice 3 19 Jun 1974	Structural Sandwich Composites
NASA NSSDC 76-06 Dec 1976	AP-8 Trapped Protons Environment for Solar Maximum and Solar Minimum
NASA NSSDC 77-05 7 1984	An Inter Outer Zone Electron Model AEI- (Hi)
NIH Pub No 85-23	Guide for Care and Use of Laboratory Animals, U.S. Department of Revised 1985 Health and Human Services, Public Health Service, National Institutes of Health
AFM 88-3 Feb 1982	Seismic Design for Buildings
DOD-D-1OOC	Engineering Drawing Practices
STDN 101.1 Revision 3 Jul 1978	Spaceflight Tracking and Data Network User's Guide (Basic)
STDN 101.2 Revision 6 Sep 1988	Space Network (SN) User's Guide
ESMCE 127-1 30 Jul 1984	Range Safety
FED-STD-2O9B 24 Apr 1973 Amendment 1 30 May 1976	Clean Room and Work Station Requirements, Controlled Environment
MIL-HDBK-217E 27 Oct 1986	Reliability Prediction
MIL-HDBK-340 (USAF) 01 Jul 1985	Application Guidelines for MIL-STD-1540B; Test Requirements for Space Vehicles
DOD-HDBK-343 (USAF) 01 Feb 1986	Design, Construction, and Testing Requirements for One of a Kind Space Equipment

STDN 408	TDRSS and GSTDN Compatibility Test Van Function Capabilities
MIL-STD-454K 14 Feb 1986 Notice 1 19 Aug 1986 Notice 2 26 Feb 1987 Notice 3 10 Sep 1987	Standard General Requirements for Electronic Equipment
MIL-STD-461C Susceptibility 04 Aug 1986 Notice 1 01 Apr 1987	Electromagnetic Emission and Requirements for the Control of Electromagnetic Interference
MIL-STD-462 31 Jul 1967 Notice 1 01 Aug 1968 Notice 2 01 May 1970 Notice 3 09 Feb 1971 Notice 4 01 Apr 1980 Notice 5 04 Aug 1986 Notice 6 15 Oct 1987	Electromagnetic Interference Characteristics, Measurement of
MSFC-SPEC-522 18 Nov 1977	Design Criteria for Controlling Stress Corrosion Cracking
MIL-STD-785B 03 Jul 1986	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810D 19 Jul 1983 Notice 1 31 Jul 1986	Environmental Test Methods and Engineering Guidelines
810-5 Vol I Revision D 15 Apr 1987	Deep Space Network/Flight Project Interface Design Handbook
MIL-STD-889 07 Jul 1976 Notice 1 21 Nov 1979	Dissimilar Metals

MIL-STD-965A 13 Dec 1985 Notice 1 10 Dec 1987 Notice 2 11 Feb 1988	Parts Control Program
MIL-STD-970 01 Oct 1987	Standards and Specifications, Order of Preference for the Selection of
MIL-STD-975F	NASA Standard Electrical, Electronic and Electromechanical (EEE) Parts List
MIL-STD-1246B 04 Sep 1987	Product Cleanliness Levels and Contamination Control Program
MIL-STD-1247B 20 Dec 1968	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missiles and Space Systems
MIL-STD-1472C 02 May 1981 Facilities	Human Engineering Design Criteria for Military Systems, Equipment and
MIL-STD-1512	Electroexplosive Subsystems, Electrically Initiated, Test Methods and Design Requirements
MIL-STD-1515A 12 Jul 1978 Notice 1 24 Sep 1979 Notice 2 05 Jun 1981 Notice 3 24 Jun 1983	Fasteners Used in the Design and Construction of Aerospace Mechanical Systems
MIL-STD-1522 28 May 1984 Notice 1 21 Dec 1984 Notice 2 20 Nov 1986	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
MIL-STD-1539 (USAF) 01 Aug 1973	Electric Power, Direct Current Space Vehicle Design Requirements
MIL-STD-1540B (USAF) 10 Oct 1982	Test Requirements for Space Vehicles
MIL-STD-1541 (USAF)	Electromagnetic Compatibility Requirements for Space Systems

MIL-STD-1542 (USAF) 15 Apr 1974	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities
MIL-STD-1568A 24 Oct 1979 Weapon	Materials and Processes for Corrosion Prevention and Control in Aerospace Systems
MIL-STD-1576 (USAF) 31 Jul 1984	Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems
NHB 1700.1 (V1-A)	NASA Basic Safety Manual
NHB 1700.7	NASA Safety Policy and Requirements for Payloads Using the Space Transportation System (STS)
NSS/HP 1740.1 22 Feb 1984	NASA Aerospace Pressure Vessel Safety Standards
MIL-F-3142A (USAF) 01 Dec 1969	Forging, Titanium Alloys, for Aircraft and Aerospace Applications
MIL-E-4158E (USAF) 11 Jan 1973	Electronic Equipment Ground: General Requirements for
JPL D-4446 (633-507) 22 Apr 1987	Satellite System Product Assurance Approach
NHB 5300.4 (3A-1)	Requirements for Soldered Electrical Connections
MIL-F-7179F 25 Sep 1984 Amendment 1 20 May 1985	Finishes and Coatings, General Specification for Protection of Aerospace Weapon Systems, Structures, and Parts
MIL-F-7190B 16 Dec 1985	Forging, Steel, for Aircraft and Special Ordnance Applications
SP-8013	Meteoroid Environment Model-Near Earth to Lunar Surface
MIL-A-8421F General 25 Oct 1974	Air Transportability Requirements, Specification for

DOD-E-8983C 29 Dec 1977	Electronic Equipment, Aerospace Extended Space Environment, General Specification
MIL-P-9024G (USAF) 06 Jun 1972	Packaging, Handling, and Transportability in System/Equipment Acquisition
MIL-A-22771D 30 Jan 1984	Aluminum Alloy Forgings, Heat Treated
MIL-P-26536C Amendment 2 01 Feb 1982	Propellant, Hydrazine, High Purity Grade
MIL-P-27401C 20 Jan 1975	Propellant, Pressurizing Agent, Nitrogen, Grade C
MIL-P-27407A (USAF) 28 Nov 1978	Propellant, Pressurizing Agent, Helium, Grade B
MIL-H-46855B Military 31 Jan 1979	Human Engineering Requirements for Systems, Equipment and Facilities
NASA-TMX 64627	Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development
DOD-W-83575A Testing (USAF) 22 Dec 1977	Wiring Harness, Space Vehicle Design and
MIL-5-83576 and (USAF) 01 Nov 1974	Solar Cell Arrays, Space Vehicle Design Testing, General Specification for
DOD-A-83577A (USAF) 15 Mar 1978	Assemblies, Moving Mechanical, for Space Vehicles, General Specification for
DOD-E-83578A (USAF) 15 Oct 1987	Explosive Ordnance for Space Vehicle, General Specification for
	Nutrient Requirements of Laboratory Animals, 3rd ed., Number 10, National Academy of Sciences, 1978
	Spacelab Payload Accommodation Handbook
	Delta II Payload Planner's Guide

2.2 NON-GOVERNMENT

RRS-IFS-101 Feb 1991	Vehicle/Payload Interface Specification for the Reusable Reentry Satellite (RRS)
RRS-IFS-102 TBD	Vehicle Telemetry Interface Specification for the Reusable Reentry Satellite (RRS)
RRS-IFS-103 TBD	Reusable Reentry Vehicle (RRV)/Expendable Launch Vehicle (ELV) Interface Specification for the Reusable Reentry Satellite (RRS)
RRS-MS-200 TBD	Mission Support (MS) Segment Peculiar Support Equipment (PSE) Specification
RRS-PS-200 Feb 1991	Segment Specification for the Payload Segment (PS) of the Reusable Reentry Satellite
RRS-RRV-200 Feb 1991	Segment Specification for the Vehicle Segment (VS) of the Reusable Reentry Satellite
RRS-IFS-201 TBD	Experiment Module (EM)/Support Module (SM) Interface Specification for the Payload Module (PM) of the Reusable Reentry Satellite (RRS)
RRS-IFS-202 Feb 1991	Main Module (MM)/Deployed Module (DM) Interface Specification for the Reusable Reentry Vehicle (RRV) of the Reusable Reentry Satellite

3.0 REQUIREMENTS

The RRS design shall provide a relatively inexpensive method of access to micro and fractional gravity space environments for an extended period of time, with eventual intact recovery on the surface of the Earth.

3.1 SYSTEM DEFINITION

3.1.1 General Description. The RRS consists of a Reusable Reentry vehicle (RRV) that transports and supports a mission-unique Payload Module (PM). The RRV, a compact reentry vehicle for launch and recovery, separates into two connected modules of approximately equal mass to meet power and payload environmental (radiation/gravity) requirements during on-orbit operations. The artificial gravity environment (.1 to 1.5 g), created by rotating the vehicle around its center of gravity, can be varied by controlling the spacecraft spin rate. The vehicle attitude is precisely controlled through use of Inertial Measurements Units (IMU), thrusters, momentum wheels and earth sensors. Satellite control, and payload interaction, is accomplished through periodic uplink of stored command programs via the NASA Tracking and Data Network (NATDN).

The RRS satellite is designed to be launched (Figure 1) either as a single launch payload, or may be "piggybacked" to provide tandem launch capability of two RRS satellites.

The RRS System (Figure 2) consists of the Payload Segment (PS), Vehicle Segment (VS), and Mission Support (MS) Segment. The ten functional subsystems distributed (Figure 3) among the four modules of the RRV and PM, and the Launch Vehicle Adapter (LVA). These subsystems and

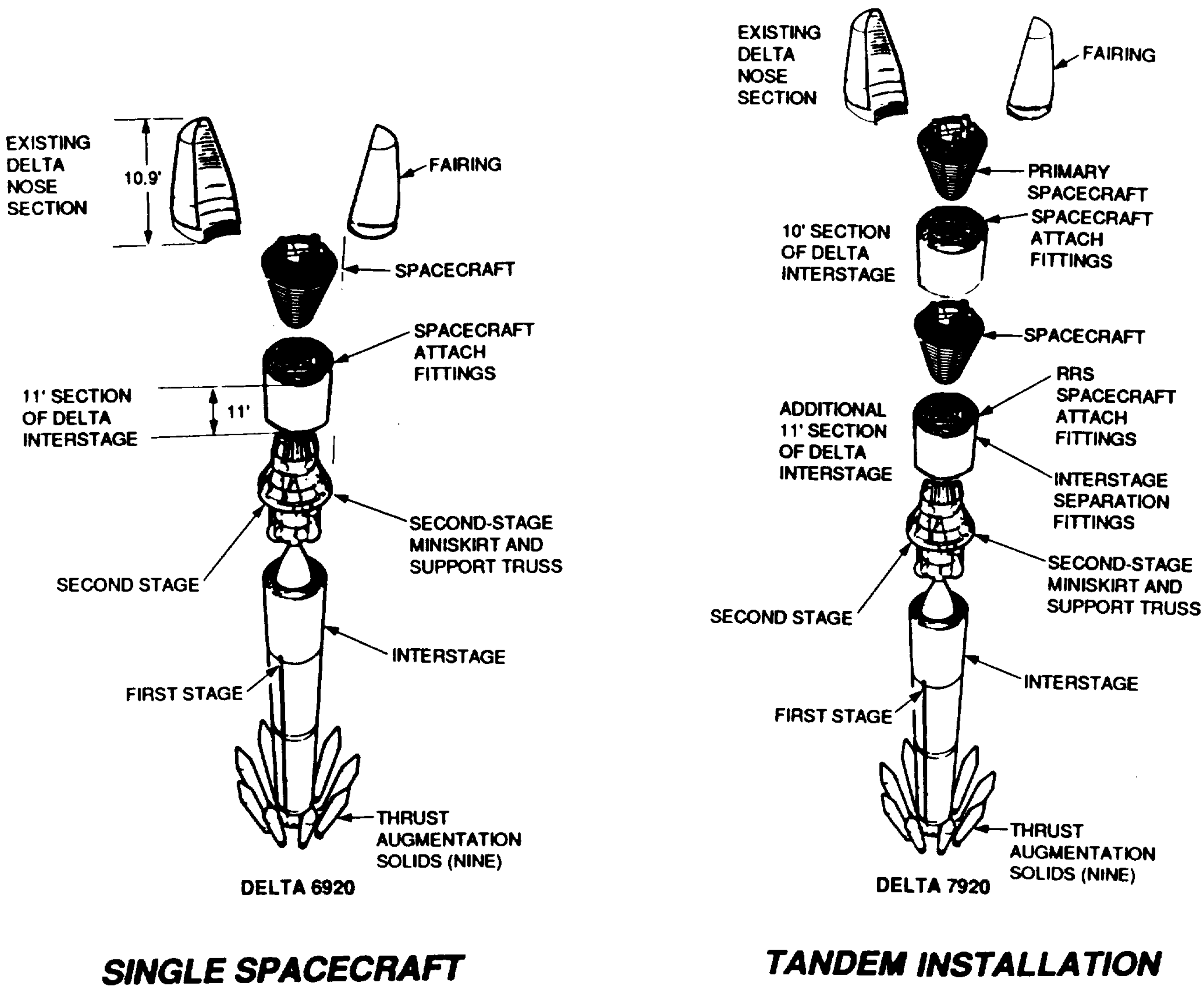

Figure 1. Launch Vehicle Installation

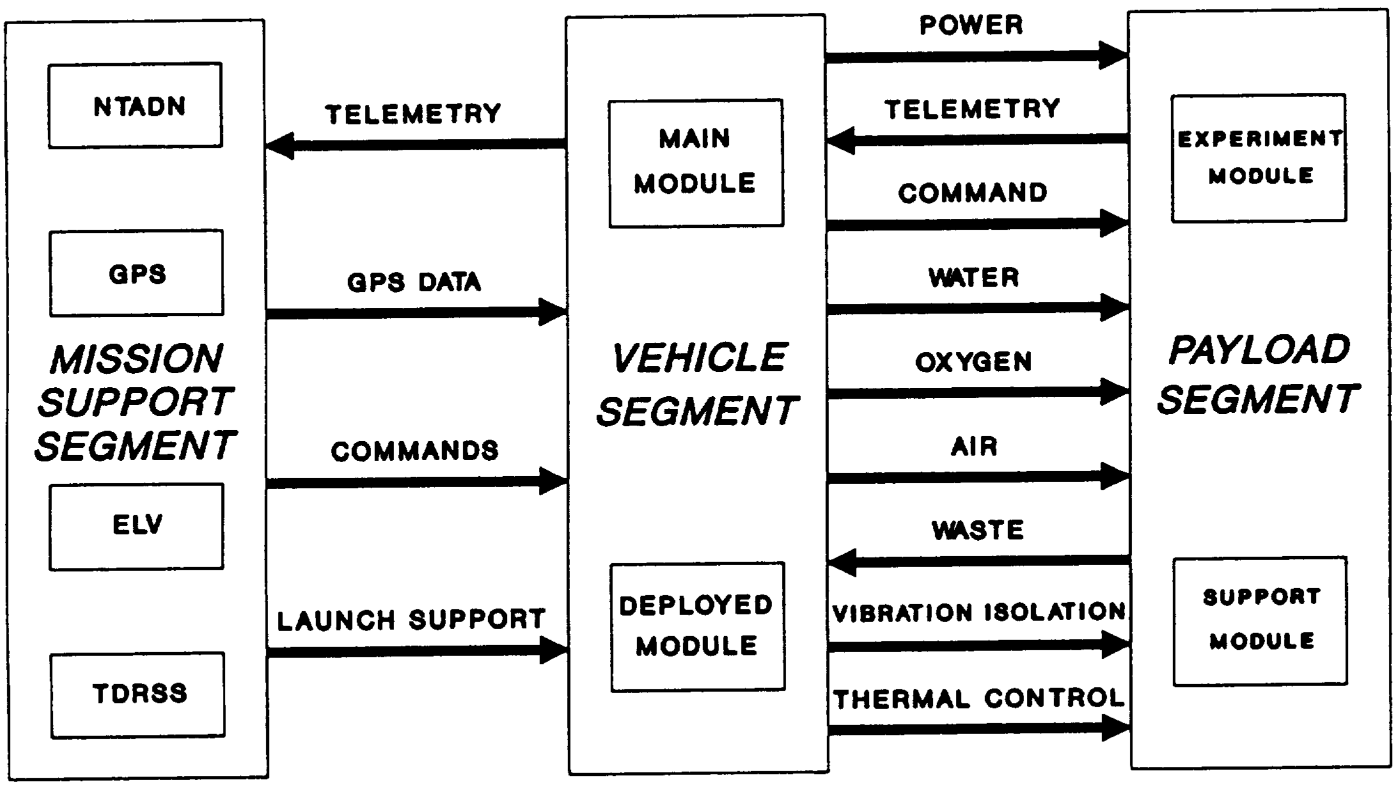

Figure 2. RRS Functional Diagram

- SYSTEM SPECIFICATION ORGANIZED BY MODULE/SUBSYSTEM
- SUBSYSTEM SPECIFICATIONS ORGANIZED BY SUBSYSTEM/MODULE

Subsystem	Main Module	Depl Module (Cont Assy)	Depl Module (Prop Assy)	Payload Module	LV Adapter
Propulsion	-------	-------	De-orbit Attitude Cont	-------	Gas Deploy
GNC	GPS Rec/Ant IMU (1) Dual MWheel	Control System IMU (2) Dual MWheel GPS System Magnetic Sys Scanner Sys	GPS Ant (3)	-------	-------
TT&C	Data Interface SOH TLM	Com/Cmd/Dec SOH TLM Data Handling Memory	Antenna	Data Module SOH TLM Camera System	Booster TLM
Power	Conv/Control Batteries	Conv/Cont Batteries Solar Array	-------	Cont/Cont Lighting	Deploy Control
Reentry	Heat Shield	-------	-------	-------	-------
Thermal	Radiator	Passive	Passive	HE/R/P/Ctl	-------
Structure	Primary	Primary Astromast	Primary	Pressure Vesl Cage Assy	Primary RRV Interface
ECLSS	Storage	-------	-------	ECLSS	-------
Recovery	-------	-------	Parachute Deploy Mech	-------	-------
Harness	Power, Control & Data	Power, Control & Data	Power, Control & Data	Power, Control & Data	Power, Control & Data

Figure 3. RRS Subsystem Distribution

their interaction are described in the segment (RRS-PM-200, RRS-VE-200) and interface (RRS-IFS-101) specifications.

3.1.1.1 Payload Segment (PS). The PS is composed of multiple Payload Module (PM) configurations, a Payload Module Emulator (PME), and a Ground Control Experiment Module (GCEM).

a) The PM (Figure 4) contains the experiment specimens and support equipment. Although the PM internal design is determined by the user, the design must be compatible with RRS-IFS-101, RRV/PM Interface Specification. Anticipated PM configurations planned for use are:

1) ESA Botany Module (EBM)

2) General Biology Module (GBM)

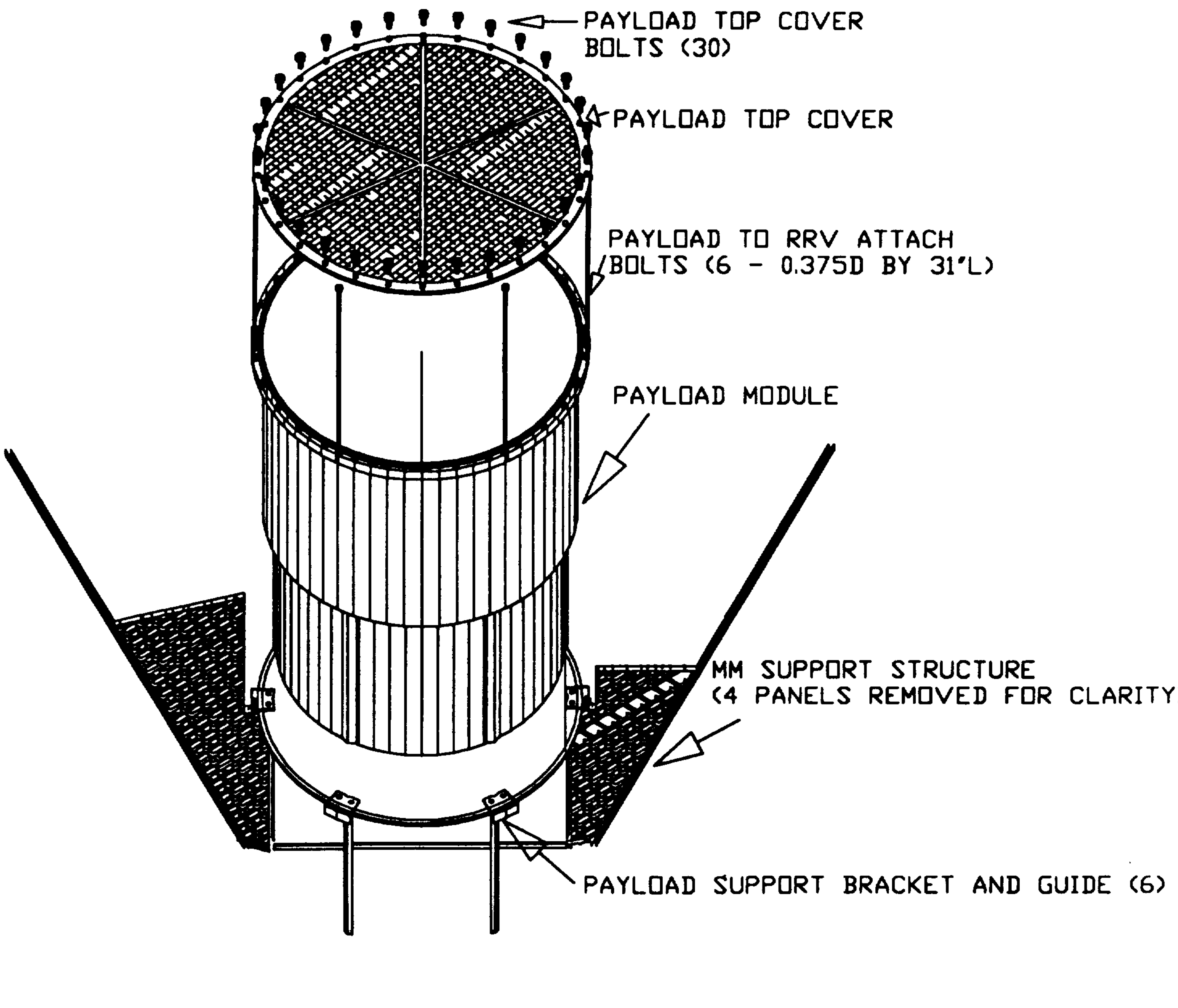

Figure 4. RRS Payload Module

3) Rodent Module (RM). The RM (Figure 5) contains the cage facilities, environmental support, and data collection capabilities to support 18 600 gram rats for a mission lifespan of 60 days.

b) The GTM is a non-flight version of the generic PM, and is used to generate experiment control data. The GTM outputs ground test data to the Vehicle Emulator (VE) and accepts commands from the VE to run ground experiments.

c) The Payload Module Emulator (PME) emulates the PM/GTM electrical and mechanical properties and interfaces to permit full validation of the RRV/PM interface using the RRV and/or VE.

d) The Ground Control Experiment Module (GCEM) consists of a GTM installed in a VE. The GCEM can be used to exactly duplicate all on-orbit experiment activities, with the exception of microgravity or fractional gravity conditions. This configuration is designed to serve as the experiment control, allowing the user to measure the differences between duplicate activities when exposed to different gravitational environments (See Addendum A).

3.1.1.1.1 Experiment Module (EM). For the Rodent Module configuration, the EM houses and supports living payloads and contains the cages, lighting, food, water, atmosphere, instrumentation, waste control, ventilation, and imaging. Environmental conditions imposed on the EM will be a result of the RRV/PM environmental impositions as well as the RRV/PM and EM/PM attenuation capabilities.

3.1.1.1.2 Support Module. The SM consists of the pressure vessel, Environmental Control/Life Support System (ECLSS), imaging system, lighting harness, instrumentation assembly, waste container, and supporting structure, as well as the requisite interconnectors, wiring harness, external interface connectors, tubing runs, and attach fittings. The SM interfaces with the VS to store and transmit experimental data, receive commands, and transmit State of Health (SOH) data.

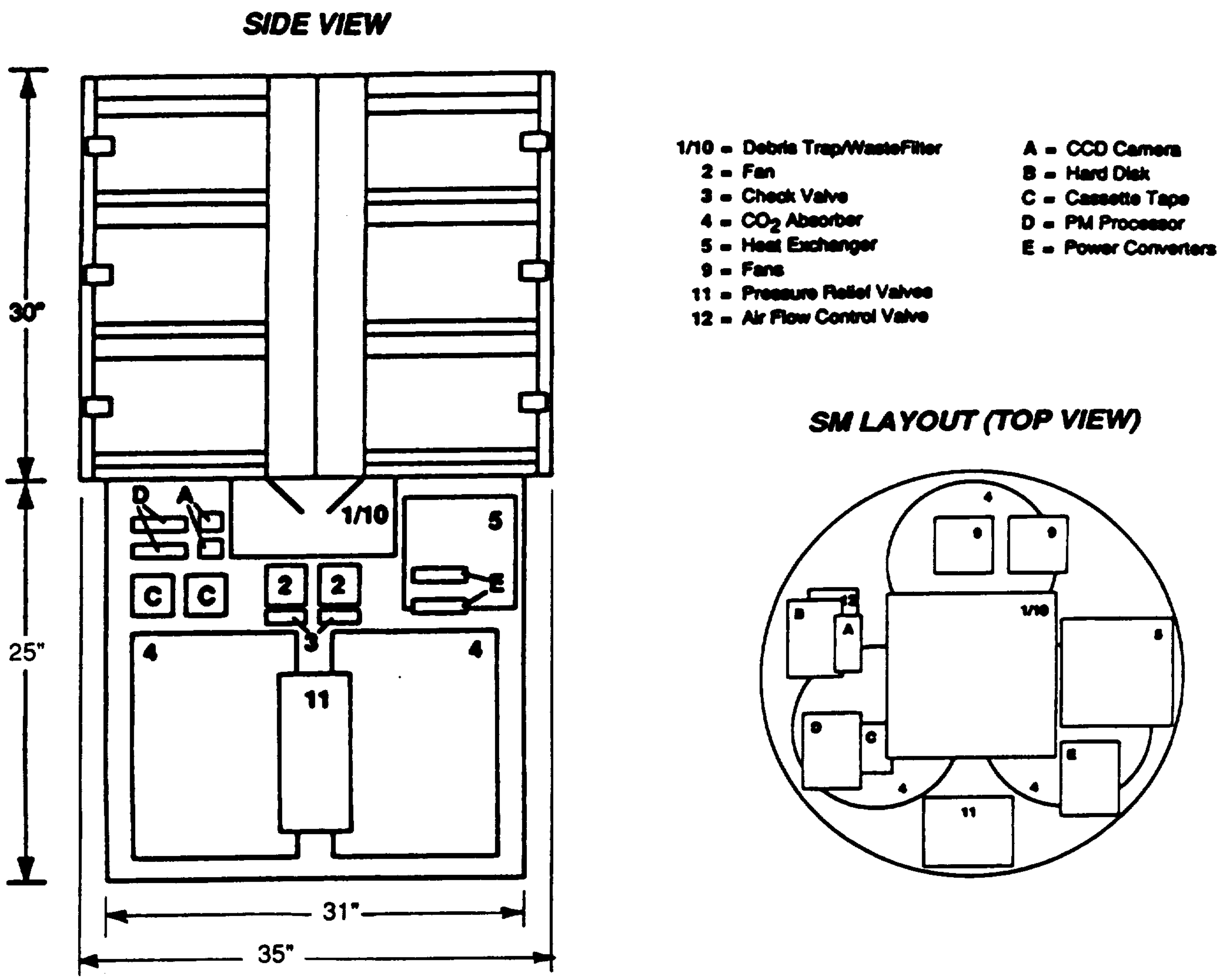

Figure 5. RRS Rodent Module

3.1.1.2 Vehicle Segment (VS). The Vehicle Segment is composed of the RRV and VE. The VS supports and maintains the PM in orbit during a mission, provides ground command and control interfaces, and stores PM consumables.

a) The RRV (Figure 6) is the host vehicle, and is composed of the Deployed Module (DM) and the Main Module (MM).

b) The VE emulates the RRV MM for the PM testing, as well as the GCEM, providing identical interface support to the PM, and relaying ground experiment data to the Peculiar Support Equipment (PSE).

3.1.1.2.1 Deployed Module (DM). The DM provides power, guidance and control, propulsion, and telemetry capability for the RRV. It also stores and controls the Astromast assembly, used to extend the Main Module to its deployed position.

3.1.1.2.2 The MM houses the PM, tanks for PM consumables, data storage, battery power, and includes the reentry heat shield.

3.1.1.3 Mission Support (MS) Segment. The MS Segment satisfies RRS launch, orbital support, and general ground support functions. It is composed of the NTADN, the Expendable Launch Vehicle (ELV) element, and PSE.

3.1.1.3.1 NTADN. The NTADN provides on-orbit command and control to the RRS, receives downlink telemetry from the RRS, and provides experimental data to the Principal Investigator (PI).

3.1.1.3.2 PSE. The PSE provides temporary thermal and power support for the RRS during pre-launch and post-recovery activities via the Power Thermal Pack (PTP), provides for duplication of the NTADN command and control for ground testing, and retrieval of ground control

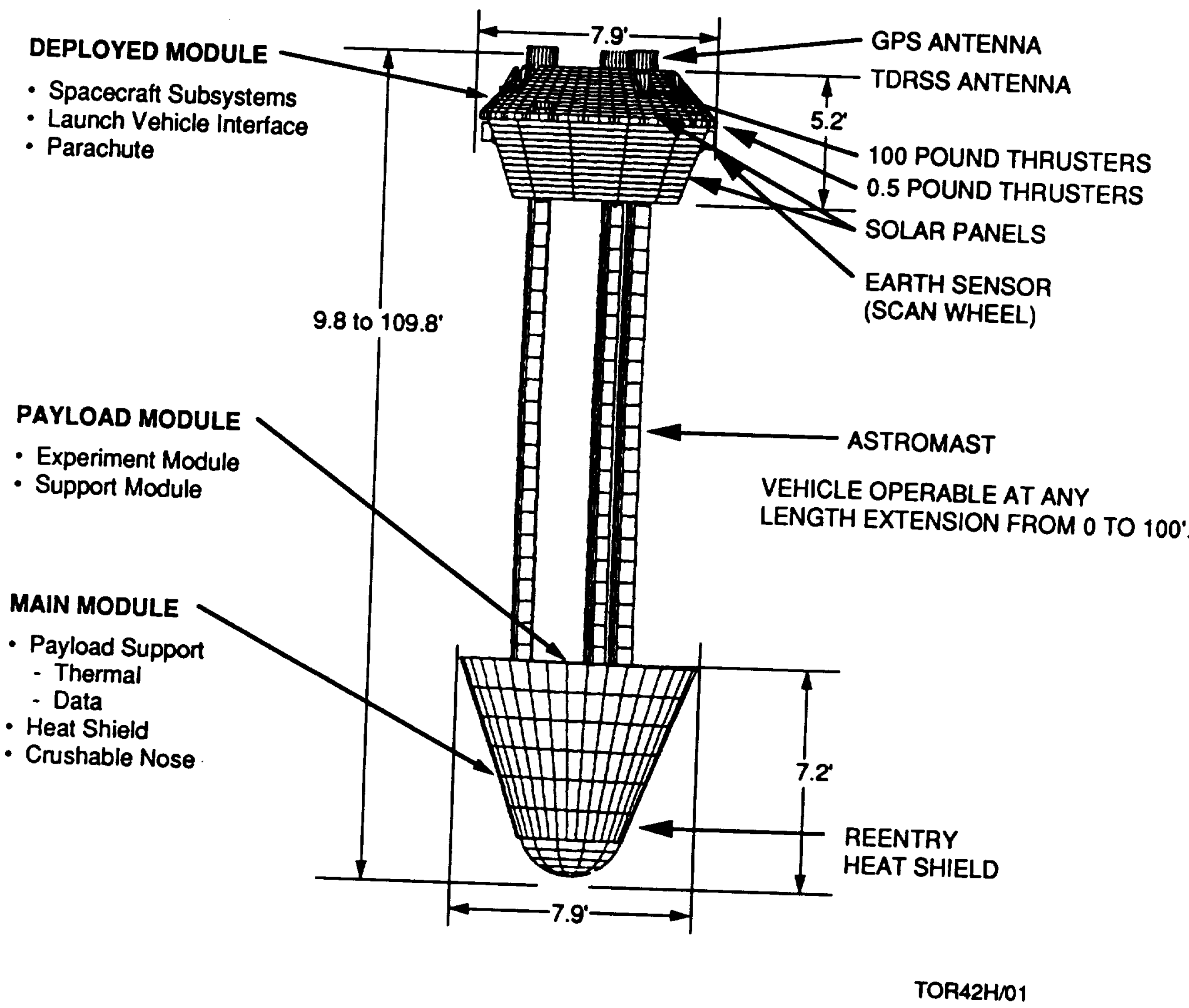

Figure 6. RRS Reusable Reentry Vehicle

experiment data via the Command and Control Emulator (C^2E).

3.1.1.3.3 ELV. The ELV provides the capability of injecting the RRS into desired operational orbits.

3.1.2 Mission. The primary mission of the RRS is to provide a relatively inexpensive method of access to microgravity and fractional gravity space environments for an extended period of time, with eventual intact recovery on the surface of the Earth. An RRS mission consists of all activities (payload selection, integration, orbital operations, recovery, data retrieval), including ground control experiments, which relate to a single launch. A single system cycle will consist of six phases from pre-launch planning through refurbishment for the next flight.

3.1.2.1 Pre-launch. Consists of payload selection, mission planning, experiment verification, and biocompatibility testing activities. Includes Payload Module, Reusable Reentry Vehicle, and Expendable Launch Vehicle checkouts performed in parallel, and final integration at the launch facility.

a) PM Checkout. The PM checkout is done using the RRS Vehicle Emulator, and simulates on-orbit operating conditions with the exception of any gravitational environment other than 1 g.

b) RRV Checkout. The RRV checkout uses the PME, and is identical to the on-orbit operation with the exception of the gravitational environment.

c) ELV Checkout. TBD.

d) Launch Site Preparation. Launch site preparations consist of:

   1) Installation and checkout of the booster at the launch facility.

2) Installation and checkout of the RRS primary Payload Adaptor.

3) In the event of a tandem RRS launch, the payload mating adaptor will be installed and checked out.

e) Integration. Final integration consists of the mating of the RRV into the adaptor, the PM into the RRV, and installation of the launch vehicle nosecone.

1) If the PM(s) consists of both Experiment and Support Modules, the Support Module will be integrated first, to permit the experimental specimens to be installed after full system checkout.

2) In the case of a tandem RRS launch, both RRSs are integrated in parallel, with the launch vehicle nosecone attached to the upper RRS assembly. The upper RRS assembly would then be mated to the lower RRS.

3.1.2.2 Launch. Launch operations, defined as first motion to RRS separation, consist of the insertion of the RRS(s) into final orbit and release of the RRS(s) from the ELV.

a) The RRS will be launched in a fully operational mode, with the exception of the momentum wheel assemblies which will be non-operating during powered flight. Final IMU and GPS calibration checks will be made immediately prior to launch, and will provide independent flight data during the boost phase.

b) The booster will insert the RRS into final orbit with no planned orbital correction using the RRV propulsion subsystem. The nosecone will be released during powered flight, and the RRS(s) released from the PA following powered flight.

3.1.2.3 Orbital Flight. Begins upon insertion (RRS separation) and concludes with first de-orbit command. Mission operations will consist of the initial on-orbit checkout, and microgravity and/or artificial gravity operations.

a) Mission Readiness. The initial on-orbit checkout will consist of:

1) in the closed configuration:

a) verification of booster/vehicle separation and correct orbital insertion. In the case of a tandem launch, the initial operation will also include the separation of the vehicle assemblies and any separation maneuvering. Other operations may include use of the RRS GN&C/propulsion capability to:

1) Reorient the vehicle and/or initiate rotisserie thermal control to improve thermal conditions for the initial operations, and

2) Correct any orbital insertion error or ensure a safe reentry of the total assembly in the case of a failure to release.

b) verification of correct RRS operation.

2) separation of the vehicle into the appropriate mission configuration.

b) Mission Operations. Mission duration will be from a few up to a maximum of 60 days. Altitudes will range from 350 to 900 km. AC power transmission is used between modules to preclude interaction with the Earth's magnetic field.

1) Microgravity. Microgravity operation will consist of orienting the vehicle into the appropriate attitude, extending the Astromasts to the required length, establishing magnetic torque attitude control operations, and initiating rotisserie thermal control.

2) Artificial Gravity. Artificial Gravity operation is initiated from, and terminated into, the microgravity mode using the propulsion attitude control thrusters. The vehicle rotation lies in the plane containing the vehicle center of gravity and the center of the Earth.

c) Recovery Preparations. The vehicle control system alignment is calibrated for reentry and the vehicle returned to the compact reentry configuration.

3.1.2.4 <u>Recovery Phase</u>. Composed of De-orbit, Reentry and Terminal Phases.

3.1.2.4.1 De-orbit Phase. This phase begins with the first de-orbit command (Main Burn Initiation) continues to the aerodynamic reorientation for reentry.

3.1.2.4.2 Reentry Phase. This phase begins with completion of aerodynamic reentry alignment (end of de-orbit) and continues until pilot chute deployment. The reentry deacceleration shall not exceed 15 g axial nor TBD g lateral.

3.1.2.4.3 Terminal Phase. This phase begins with pilot chute deployment and continues until landing. The RRS shall have a near-vertical descent from an altitude of at least 60,000 feet with a 3 sigma impact dispersion of no more than ± 6 km crossrange and ± 30 km downrange. The atmospheric braking shall not exceed 2 g axial. Impact shall not exceed 10 g any axis.

3.1.2.5 Post-Recovery Phase. This phase begins with landing and continues until the experiment and data are delivered to the PI and any simultaneous ground control experiments are completed. Physical access to the PM and removal of the flight animals shall be ≤ 2 hours, with thermal/electrical support via Ground Support Equipment (GFE) within 30 minutes of landing, and delivery of the RRS to the post recovery facility within 90 minutes.

3.1.2.6 Refurbishment. The disassembly, inspection, cleaning and repair necessary to return the RRV and PM hardware to flightworthy condition. The RRV shall be ready for integration with another PM within 60 days of recovery from the prior mission.

3.1.2.7 Ground Control Experiment. Tests which (1) verify the experiment design, (2) verify the hardware

biocompatibility and performance, and (3) serve as controls for the flight experiments.

3.1.3 Threat

3.1.3.1 Solar activities. Excessive ionizing radiation resulting from solar flares.

3.1.4 Interface Definition. The RRS segments and element interface requirements shall be as specified in the appropriate interface specifications, as listed below.

a) RRV-to-PM interface - RRS-IFS-101.
b) RRV-to-MS interface - RRS-IFS-102.
c) RRV-to-ELV interface - RRS-IFS-103.
d) EM-to-SM interface - RRS-IFS-201.
e) MM-to-DM interface - RRS-IFS-202.
f) PM-to-MS interface - No direct interface.

3.1.5 Major Component List. The RRS consists of the elements indicated in 3.1.1 and subparagraphs, as further defined in the appropriate segment specifications.

3.1.6 Government Furnished Property (GFP) List

a) The RRS shall incorporate the GFP and Government Furnished Resources (GFR) identified elsewhere in the contract.

b) The GFP and GFR shall detail any Government Furnished Information (GFI) and Government Furnished Software (GFS) as specified by Computer Software Configuration Items (CSCIs) or specified algorithms that are proposed to be included in the system.

3.1.7 Government Loaned Property (GLP) List. The RRS shall make use of government equipment/assets defined in the GLP List elsewhere in the contract.

3.1.8 Operational and Organizational Concepts

a) The RRS shall be designed to provide the Principal Investigator the capability to recover his/her experiments with a very high degree of probability.

b) The RRS shall be designed to enable the PI to design, develop, test, and integrate hardware to support experiments in a self-supporting mode.

c) The RRS shall contain elements to facilitate testing and integration of the RRV and the PM. A particular element shall be designed to provide/emulate identical interfaces and identical functional and data responses, when feasible.

d) The RRS shall be designed to enable economical refurbishment and to facilitate maintenance tasks.

e) The design of Payload and Vehicle segments shall be such that it will enable the government to use either space- or ground-qualified parts for ground elements.

f) The interface between the Vehicle and Payload segments shall be uniquely defined. All VS and PS elements will use the same interface structure.

3.1.9 Specification Tree. The specification tree outlining the RRS System/ Segment Specifications and Interface Specifications (IFSs) shall be as depicted in Figure 7. A document identification number has been placed on all RRS-unique documents. In the Payload Segment Specification, only the internal structure for the RM is shown in detail; a similar set is required for the ESA Botany Module (EBM) and General Biology Module (GBM).

3.2 CHARACTERISTICS

3.2.1 System Characteristics

3.2.1.1 Mission

3.2.1.1.1 Mission Duration. The RRS shall support missions of at least 60 days each.

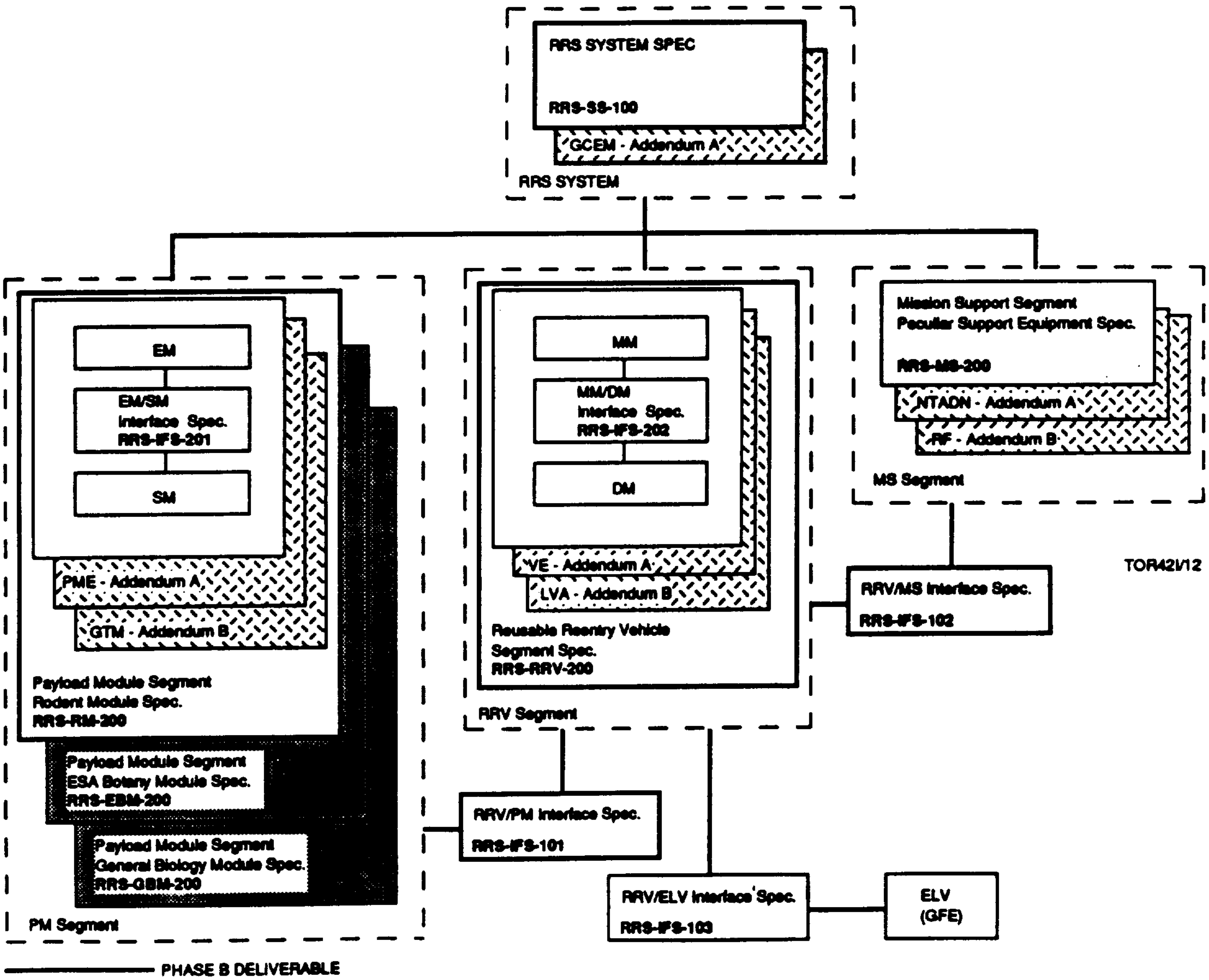

Figure 7. RRS Program Specification Matrix

3.2.1.1.2 Mission Life. The RRS mission life shall be a minimum of 1800 days. Mission life is defined as the time from insertion of the EM into the PM to the removal of the PM or EM times the number of missions.

3.2.1.1.3 Mission Minimum. The RRS shall withstand a minimum of 30 missions, with a design goal of 3 missions per year for 10 years.

3.2.1.1.4 Operational Life. RRS equipment shall be designed for an operational life of at least 10 years.

3.2.1.2 System Capability

3.2.1.2.1 System Capacity

3.2.1.2.1.1 System Capacity - Weight/Size. System capacity shall be as defined in the RRS Interface Specification RRS-IFS-101.

3.2.1.2.1.2 System Capacity - Duration. System capacity shall be sized to provide experiment support for 60 days.

3.2.1.2.1.3 System Capacity - Design Margin. System capacity shall be sized with 25% to 50% design margins for consumables and waste.

3.2.1.2.2 Experiment Installation and Closeout. Final experiment installation shall be completed at ≤T-12 hours and final closeout at <T-4 hours.

3.2.1.2.3 Post-flight Experiment Access. Physical access to the PM and removal of the experiment specimens shall be < 2 hours.

3.2.1.2.4 Pseudo-Gravity. The RRS shall produce a pseudo-gravity environment that can vary from microgravity (10^{-3} g maximum with < 10^{-5} g > 95% of the time) to artificial gravity (0.1 g to 1.5 g (1.0 g for animals) controlled to + 10%).

3.2.1.3 Operational Orbits. The RRS shall have the capability of operating and returning from orbits within the altitude range of 350 to 900 kilometers with inclinations between 34° and 98°.

3.2.1.4 Reentry

3.2.1.4.1 Deceleration. The reentry deceleration shall not exceed 15 g axial.

3.2.1.4.2 Atmospheric Braking. The atmospheric braking shall not exceed 2 g axial.

3.2.1.4.3 Impact. Impact shall not exceed 10 g any axis.

3.2.1.5 Reusability

3.2.1.5.1 Clearance. All RRS elements identified to be refurbished shall be designed with adequate clearance for ease of insertion/removal.

3.2.1.5.2 Refurbishment. The RRS shall be designed to allow its elements to be refurbished. Refurbishment is defined herein as those tasks consisting of disassembly, inspection, cleaning, and repair after a flight in order to render the hardware flightworthy.

3.2.1.5.4 Reusability During Mission Life. The RRS shall be designed in a manner that its elements are reusable during the RRS mission life.

3.2.2 Segment Characteristics

3.2.2.1 Payload Segment. See Payload Segment Specification RRS-PS-200.

3.2.2.2 Vehicle Segment. See Vehicle Segment Specification RRS-RRV-200.

3.2.2.3 Mission Support Segment. See Mission Support Segment Specification RRS-MS-200.

3.2.3 Reliability

The satellite design shall incorporate block, functional, and/or alternate mode redundancy so as to avoid mission-catastrophic single-point failures. A catastrophic failure is defined as an irrecoverable condition of satellite bus performance.

3.2.3.1 Quantitative Reliability Requirements

3.2.3.1.1 Experiment Parameters

3.2.3.1.1.1 Experiment Success. The PM shall be designed to satisfy all science and safety requirements and to provide a probability of experiment success of at least 95%.

3.2.3.1.1.2 Animal Welfare. The RRS shall be designed to provide a probability of successful recovery of healthy experimental animals of at least 99%.

3.2.3.1.2 Reliability Allocation. The reliability requirements of the RRS segments shall be as specified in RRS Final Report, Appendix D. The operational requirements for each of the parameters includes the combined effects of item design, quality, operation, maintenance, and repair in the operational environment.

3.2.3.2 Qualitative Reliability Design Requirements

3.2.3.2.1 Failure Isolation. The RRS shall be designed such that a failure in one unit shall not propagate in a manner which permanently degrades performance of another unit or subsystem.

3.2.3.2.2 Graceful Degradation. The RRS shall be designed to provide the capability of performing in a graceful degraded mode upon failure until repairs or corrective actions are implemented.

3.2.3.2.3 Redundancy

a) Redundancy shall be applied at all levels to eliminate critical failure modes and single point failures.

b) The RRS design shall allow for the activation and bringing into service of standby units with a minimum of disturbance to the vehicle or PM.

3.2.3.2.4 Single Component Failure

3.2.3.2.4.1 Equipment. The failure of a single RRS component shall not cause secondary failures in the RRS equipment.

3.2.3.2.4.2 Interface Equipment. The failure of a single RRS component shall not cause secondary failures in interface equipment.

3.2.3.2.5 Single Point Failure (SPF). Single point failures are to be designed out of the system unless the added cost and complexity is not justified for the specific probability of failure and mission impact.

3.2.4 Maintainability. The design of each newly developed or modified item:

a) Shall meet the maintainability requirements in paragraphs 3.2.4.1 through 3.2.4.6

b) Shall be such that failure, damage or removal of one item will not cause damage or failure in any other item.

c) Shall be designed so as to minimize the use of special fixtures (e.g., extended cards) for functional isolation procedures; should be in the operational configuration during functional isolation.

d) Shall have items which are physically self-supporting during prescribed maintenance and which can be placed on a work bench without damage.

e) Shall have accessibility of physically isolatable items in accordance with MIL-STD-454, requirement 36.

f) Shall have test points in accordance with MID-STD-454, requirement 32.

g) Shall have easily removable subassemblies, when feasible.

h) Shall have interchangeable replacement items.

i) Shall have easily and correctly replaceable items, which should not fit in the wrong location or orientation.

j) Shall have accessible adjustments

k) Shall have the minimum number of adjustments necessary to maintain optimum equipment operation.

l) Should represent reasonable design compromises to obtain the following:

   1) Minimum maintenance technician skill level and training required.

2) Minimum tools and test equipment required.

3) Minimum number of different items (i.e., standardization of internal subsystems to enhance interchangeability).

4) Minimum connections between the system and each replaceable item.

3.2.4.1 Accessibility. RRS accessibility requirements shall be in accordance with MIL-STD-454, Requirement 36.

3.2.4.2 Preventive Maintenance Actions

a) There shall be no scheduled preventative maintenance necessary for the duration of an anticipated 60-day mission.

b) During on-orbit operation, monitoring and adjustment of critical system parameters shall not exceed 10 minutes per deficiency.

b) During storage, scheduled preventative maintenance to verify system functional operation shall not exceed 8 hours per month.

3.2.4.3 Maximum Corrective Maintenance Time (Mmax). The Mmax of all the maintenance actions at the 90 percentile shall be no greater than 1 hour.

3.2.4.4 Mean-Time-To-Repair (MTTR). The MTTR shall be no less than TBD minutes. MTTR is defined herein as the mean time required to accomplish repair on the failed equipment to put it back to operational status and is expressed as:

$$X \qquad X \qquad MTTR = \_ \ L_i \ Rp_i \ / \ \_ \ L_i$$

where L_i is the failure rate of the individual element of the equipment being measured, expressed in per million hours, and R_{pi} is the corrective maintenance repair time of the ith element of the equipment being measured,

including time elements of fault detection, localization, isolation, removal and replacement, and test/checkout (verification of restoration of equipment operability). MTTR does not include logistics supply time or administrative delay time.

3.2.4.5 Specific Maintainability Design Requirements

3.2.4.5.1 Accessibility Without Mechanical Disassembly. All parts and sealed units shall be readily accessible without mechanical disassembly for circuit checks.

3.2.4.5.2 Adjustments and Controls. Adjustments and controls normally used shall be easily accessible.

3.2.4.5.3 Dial Calibration. Dials used for changes in frequency, phase, and other sequential adjustments shall be calibrated.

3.2.4.5.4 Equipment Group Level. The capability of detection, localization, and isolation shall be accomplished to the equipment group level.

3.2.4.5.5 High Failure Rate. Parts having a high failure rate shall be given specific consideration for replacements.

3.2.4.5.6 Logical Fault Isolation Procedure. A logical fault isolation procedure, using test points and indicators, shall be developed to isolate the failure to a single Line Replaceable Unit (LRU), as much as possible, without special test equipment.

3.2.4.5.7 LRU Level. Fault detection, localization, and isolation shall be accomplished to the LRU level.

3.2.4.5.9 Test Points. Test points shall be provided in accordance with MIL-STD-1472, paragraph 5.9.15 and made accessible to facilitate the isolation of faults to a removable assembly of the LRU.

3.2.4.6 Test

3.2.4.6.1 Test Capability. The RRS shall have a test capability to isolate and/or locate faulty LRU(s) using ground support equipment.

3.2.4.6.1.1 Single Fault LRU. The isolation and/or location to a single faulty LRU shall be accomplished with a 96% probability that the selection is correct.

3.2.5 Environmental Conditions

3.2.5.1 Spacecraft Fabrication and Test Facilities

3.2.5.1.1 Air Requirements. The RRS facility shall comply with FED-STD-209, air class 100,000 requirements.

3.2.5.1.2 Explosive Atmosphere. The RRS equipment, operating in areas where a possibility of an ambient explosive atmosphere including ozone exists, shall not cause ignition of such an atmosphere.

3.2.5.1.3 Relative Humidity. The facilities shall limit relative humidity to less than 70%.

3.2.5.1.4 Temperatures. The facilities shall provide temperatures ranging from 60°F to 90°F.

3.2.5.2 Transportability

3.2.5.2.1 Packaging

a) The modes of transportation, support, and types of protective covers used shall be chosen to ensure that transportation and handling do not impose conditions exceeding those imposed by operational modes and storage requirements.

b) The RRV shall be capable of being shipped in a full-up configuration (less propellant and consumables).

3.2.5.2.2 Storage Environment. Preservation, packaging, and packing of components for storage shall be in accordance with the appropriate paragraphs of MIL-STD-810 applicable to the environments imposed by 3.2.5.2.

3.2.5.2.3 Transportation and Handling Environments. When packaged and prepared for shipment, the RRS equipment shall meet the requirements of MIL-P-9024, paragraph 3.3.

3.2.5.2.4 Altitude. While in transit, the RRS equipment shall withstand or be protected against the environments specified below.

3.2.5.2.5 Altitude Range. Sea level to 50,000 feet.

3.2.5.2.6 Pressure Change. Pressure change equivalent to a change in altitude from sea level to 2,000 feet in 1 minute.

3.2.5.2.7 Humidity. While in transit, the RRS equipment shall be packaged to withstand a relative humidity to 100% with condensation occurring in liquid and solid form.

3.2.5.2.8 Shock. The RRS equipment shall be packaged for shipment to withstand the shock requirements of MIL-STD-810, Test Method 516.3, Procedure III.

3.2.5.2.9 Vibration. While in transit, the RRS equipment shall withstand or be protected against vibration damage or handling as follows:

3.2.5.2.10 Sea Transportation. Vibration of ±1.3 g amplitude from 16 to 50 Hz.

3.2.5.2.11 Truck Transit. Vibration of ±3.0 g amplitude decaying sinusoidal wave with a decay rate of 0.05 in the frequency range of 2 to 300 Hz.

3.2.5.2.12 Temperature. While in transit, the RRS equipment shall withstand or be protected against the temperature environments specified below:

3.2.5.2.13 Air Transportation. -40°F to 150°F with a thermal gradient of 33°F per minute for five minutes.

3.2.5.2.14 Rail, Truck, and Sea Transportation. -40°F to +150°F with a thermal gradient of 5°F per minute for five minutes.

3.2.5.3 Launch, Orbital Reentry, and Landing Environments

3.2.5.3.1 Launch. The RRS shall operate satisfactorily during and after the dynamic loads imposed by the Delta launch vehicle as described in the Delta II Payload Planner's Guide.

3.2.5.3.1 Launch Acceleration. The acceleration imposed on the rodents by the launch vehicle shall not exceed 8 g's.

3.2.5.3.2 Orbital Environments. The RRS shall operate satisfactorily during and after the environments imposed on orbit with altitudes from 350 to 900 nm and inclinations from 33° to 98°.

3.2.5.3.3 Reentry. The RRS shall operate satisfactorily during and after the 15 g static load imposed by the deceleration generated by reentry in the atmosphere.

3.2.5.3.4 Landing Environment. The RRS shall operate satisfactorily during and after the 10 g shock imposed by impact with the ground.

3.2.5.4 Post Flight

3.2.5.4.1 Ground Winds

3.2.5.1.2.6.1 Mean Winds. The RRS equipment shall operate satisfactorily in winds up to 55 knots.

3.2.5.1.2.6.2 Wind Gusts. The RRS equipment shall survive against winds having gusts to 110 knots.

3.2.5.1.2.7 Humidity. The RRS equipment shall operate within a range of relative humidity from 0 to 100%.

3.2.5.1.2.8 Ice. The RRS equipment shall survive glaze ice to 1 inch at a specific gravity of 0.9.

3.2.5.1.2.9 Rain. The RRS equipment shall withstand or be protected against precipitation of 4 inches per hour for 2 hours.

3.2.5.1.2.11 Seismic. The RRS equipment shall withstand seismic disturbance equivalent to those identified in AFM 88-3, Chapter 13.

3.2.5.1.2.12 Snow. The RRS equipment shall withstand single storm snowfall of 20 lbs/ft^2 (equivalent to a depth of 40 inches at a specific gravity of 0.1).

3.2.5.1.2.13 Sunshine. The RRS equipment shall withstand or be protected against solar radiation of 360 $BTU/ft^2/hour$ for up to 4 hours per day.

3.2.5.1.2.3 Blowing Dust. The RRS equipment shall operate when exposed to 6×10^{-9} gm/cc of 0.0001-mm to 0.01-mm diameter particles carried by wind blowing 40 knots at a height of 5 feet in a temperature of 70°F.

3.2.5.1.2.4 Blowing Sand. The RRS equipment shall operate when exposed to particles of 0.18 mm to 0.30 mm diameter carried by wind blowing 40 knots at a height of 5 feet at a temperature of 100°F.

3.2.5.1.2.2.2 Equipment Temperatures. The RRS equipment, other than computer equipment, shall operate after being exposed to temperatures ranging from -50°F to +160°F.

3.3 DESIGN AND CONSTRUCTION

3.3.1 Materials, Parts, and Processes

3.3.1.1 Materials

3.3.1.1.1 Arc-Resistant Materials. Material used for insulation of electrical power circuits where arcing may occur shall be in accordance with MIL-STD-454, Requirement 26.

3.3.1.1.2 Dissimilar Metals. Selection and protection of dissimilar metal combinations shall be in accordance with MIL-STD-454, Requirement 16.

3.3.1.1.3 Fibrous Materials, Organic. Selection and use of organic fibrous material shall be in accordance with MIL-STD-454, Requirement 44.

3.3.1.1.4 Flammability. Selection and application of materials with respect to flammability shall be in accordance with MIL-STD-454, Requirement 3.

3.3.1.1.5 Fungus-Inert Materials. Selection of materials for the control of moisture and fungus resistance shall be in accordance with MIL-STD-454, Requirement 4.

3.3.1.1.6 Insulating Materials, Electrical. Selection and usage of electrical insulating materials shall be in accordance with MIL-STD-454, Requirement 11.

3.3.1.1.7 Magnesium. Usage of magnesium alloys shall be in accordance with MIL-E-4158, paragraph 3.4.7.

3.3.1.1.8 Metals, Corrosion Resistance. Parts shall be protected against corrosion in accordance with MIL-STD-454, Requirement 15.

3.3.1.2 Parts

3.3.1.2.1 Critical Items. Critical items shall be in accordance with contractual provisions. The contract will implement handling of critical items using the provisions in MIL-STD-785, Task 208. For the purposes of the contract, hybrids including RF, microwave and millimeter types, and complex monolithic circuits used in RRS

Developed Items (RDIs), will be considered critical items.

3.3.1.2.2 Derating

3.3.1.2.2.1 Parts and Materials. Derating of parts and materials shall be in accordance with MIL-STD-454, Requirement 18.

3.3.1.2.3 Part and Part Nomenclature. Part nomenclature requirements shall be in accordance with MIL-E-4158, paragraph 3.3.2.

3.3.1.2.4 Selection. Parts shall be purchased to SAIC-prepared specifications.

3.3.1.2.5 Screening. Screening of parts shall be in accordance with the requirements specified by the applicable SAIC procedures which shall reflect the specifications prepared by SAIC for parts.

3.3.1.3 Processes

3.3.1.3.1 Brazing. Brazing shall be in accordance with MIL-STD-454, Requirement 59.

3.3.1.3.2 Cable and Wire, Interconnection. Signal, ground, and power cabling required to interconnect equipment shall be in accordance with MIL-STD-454, Requirement 71.

3.3.1.3.3 Internal Wiring Practices. Internal wiring practices shall be in accordance with MIL-STD-454, Requirement 69.

3.3.1.3.4 Soldering. Soldering shall be in accordance with MIL-STD-454, Requirement 5. The electrical bonding of equipment and structural/thermal elements shall:

a) Prevent the accumulation of static charge on any structure, equipment case, metal part or conductor that could damage equipment due to electrostatic discharge.

b) Provide a low impedance path to the electrical reference point for the conduction of electromagnetic currents.

c) Prevent electromagnetic wave or current nonlinear rectification.

d) Preclude any shock hazard to personnel.

e) Provide an equipotential mass that can be used as a reference point for electrical measurements.

3.3.1.3.5 Welding

3.3.1.3.5.1 Structural Welding. Structural welding shall be in accordance with MIL-STD-454, Requirement 13.

3.3.1.3.5.2 Welds, Resistance, Electrical Interconnection. Welds, resistance, and electrical interconnections shall be in accordance with MIL-STD-454, Requirement 24.

3.3.2 Electromagnetic Compatibility. The RRS subsystems shall be designed for the control of electromagnetic emission and susceptibility in compliance with the standards of MIL-STD-462.

3.3.3 Nameplates and Marking. Identification nomenclature, marking and labelling of equipment shall be in accordance with MIL-STD-454, Requirement 67.

3.3.4 Workmanship

3.3.4.1 Enclosures. RRS equipment shall be standardized for mounting in enclosures in accordance with MIL-STD-454, Requirement 55.

3.3.4.2 Workmanship Criteria. RRS equipment, including accessories, shall be constructed in accordance with MIL-STD-454, Requirement 9.

3.3.5 Interchangeability

a) The RRS shall be designed such that all components, modules, subassemblies, and assemblies identified by the same part number shall be physically and functionally interchangeable except where special fitting or matching is required.

b) Equipment items identified as being interchangeable shall be interchangeable in accordance with MIL-STD-454, Requirement 7.

c) Equipment items identified as having the same manufacturer's part number shall be interchangeable in accordance with MIL-STD-454, Requirement 7.

3.3.6 Safety

a) The safety of the RRS, flight experiments, ground personnel, the public, and the prevention of property damage and damage to ground and flight hardware shall be a prime consideration in the total system design.

b) The RRS shall be designed to have a 0.997 probability of landing within the designated landing zone with any single failure.

3.3.7 Human Performance/Human Engineering. RDI and modified equipment shall be designed in accordance with MIL-STD-1472.

3.3.8 RRS Computer Resources

3.3.8.1 Microcomputer Hardware. Microcomputer hardware is defined to be either a single board computer or a microprocessor chip or chip set.

3.3.8.1.1 Memory Expansion. Microcomputer hardware shall have the capability for 100% memory expansion beyond that provided.

3.3.8.1.2 Memory Reserve. Microcomputer hardware shall provide 10% of memory reserve.

3.3.8.1.3 Microcomputer Processing Unit Reserve. Microcomputers shall provide clocking-rate reserves of 10% as calculated below.

% reserve = total capability - peak load capability
total capability

3.3.8.2 Development Computer Hardware

a) Development computer hardware is defined as a computer consisting of a standalone chassis/rack or a set of chassis/rack with its own power supply.

b) The development computer hardware shall be selected from commercial OTS (COTS) family of computers having the capability of accommodating a two-fold increase in computer resource requirements beyond that provided.

3.3.8.3 Application Software

3.3.8.3.1 Logical Completeness. Each functional level of software design shall be logically complete, with lower levels containing progressively more design-related

details. All software shall be designed in a structured top-down environment.

3.3.8.3.2 Symbolic Parameters. Duplication of symbolic parameters shall be minimized through the use of common source values.

3.3.8.3.3 Use of Software Environment. The application software shall take full advantage of the operating systems, executives, compilers, assemblers, system support software, and other system functions within the constraints in 3.3.8.4.1.3.

3.3.8.4 System Software

3.3.8.4.1 Compilers and Assemblers

3.3.8.4.1.1 Compilers and Assemblers Integrity. Compilers and assemblers shall not be altered, changed, or modified. This requirement excludes normal upgrades or new releases made by vendors.

3.3.8.4.1.2 Compilers and Assemblers Utilization. The RRS shall use either off-the-shelf compilers and assemblers or those available at existing installations.

3.3.8.4.1.3 High Order Language Compiler Selection Criteria. A High Order Language Compiler shall:

a. Be validated for use with selected mission computer hardware.

b) Utilize a known, easy-to-use, language.

c) Have a complete set of development tools.

d) Have a complete set of real-time test tools.

3.3.8.4.1.4 Prior Operational Use. Prior to beginning development, compilers and assemblers used in the RRS shall already be operational with a demonstrable record of reliability.

3.3.8.4.2 Operating Systems (OSs)

3.3.8.4.2.1 OS Integrity. OSs shall not be altered, changed, or modified. This requirement excludes normal upgrades or new releases made by vendors.

3.3.8.4.2.2 OS Utilization. The RRS shall use either off-the-shelf OSs or those available at existing installations.

3.3.8.4.2.3 Prior Operational Use. Prior to beginning development, OSs used in the RRS shall already be operational with a demonstrable record of reliability.

3.3.8.4.3 System Support Software

3.3.8.4.3.1 Commercial Development. The system support software used in the RRS shall have been, to the maximum extent possible, COTS software.

3.3.8.4.3.2 Integrated Environmental Support. The support software shall provide an integrated environment to allow the upgrading and maintenance of the application software.

3.4 DOCUMENTATION

The contractor shall deliver documentation addressing programmatic, technical, and cost areas as specified by the contracting agency.

3.5 LOGISTICS

a) Life Cycle Cost (LCC). The requirements for logistics support shall be directed toward achieving and sustaining the required readiness posture at a minimum LCC.

b) Logistic Support Analysis (LSA). The requirements shall be accomplished by using LSA to integrate the logistics elements into the operational and design concepts.

3.5.1 Maintenance

a) LRU Definition. An LRU is any item that can be removed and replaced, at the organizational level of maintenance without cutting and resoldering, and is the lowest economical assembly level based upon LCC which meets the reliability, availability, and maintainability requirements. Specific determination of LRUs shall be based upon minimum LCC.

b) Shop Replaceable Unit (SRU) Definition. An SRU is any circuit board and chassis mounted component (switch, fuse, subassembly, etc.) that can be easily removed and replaced at the intermediate level of maintenance.

3.5.2 Supply

3.5.2.1 Impact of Supply on System Design. Any new design shall make maximum use of NASA stocklisted components and parts.

3.5.2.2 Introduction of New Items to System. New items which must be introduced shall be readily procurable through recognized commercial sources.

3.5.2.3 Distribution and Location of System Stock. Replacement LRUs shall be provisioned on site to achieve specified maintainability and availability requirements.

3.5.3 Facilities and Facility Equipment. TBD

3.6 PERSONNEL AND TRAINING

Personnel shall include those required for manufacture and support of the RRS hardware. Training shall include those resources required to qualify or certify personnel for direct support of the RRS during all phases of manufacture, assembly, test, maintenance, and operations.

3.6.1 Personnel. Personnel levels and experience shall include those required to accomplish and support the following:

a) The manufacture and assembly process.

b) The operation of simulation equipment.

c) The pre-launch and launch operation and control functions at the launch site.

d) The post-launch cleanup and analysis.

e) The preparation of orbital plans, including launch, early orbit, contingency, and nominal orbit planning.

f) Participation in interface working groups.

g) The necessary test for pre-launch and launch operations.

h) Recovery and refurbishment operations.

3.6.2 Training. Training shall include equipment, services, and qualified instructor personnel. Training curriculum shall include handling and operation of the RRS during pre-launch and launch operations, and training needed for NASA personnel in mission planning and RRS operations. Training shall also include training aids and documentation which shall be provided prior to the start of training.

3.6.2.1 General Training Requirements

a) Operational Hardware Configuration Items (HWCIs) and Computer Software Configuration Items (CSCIs) used for training purposes shall be used without modification.

b) After the system has been declared operational, training shall not interfere with daily operations.

c) The capability for generating realistic training scenarios and exercised shall be provided.

d) Safeguards shall be incorporated to preclude the system from processing training and/or exercise data as if it were valid system data.

3.6.2.2 Training Phases

3.6.2.2.1 Operational Test and Evaluation (OT&E) Phase

a) The contractor shall provide training to government and government-designated personnel that will participate in the OT&E testing phase.

b) Effective use shall be made of material that will be used later for formal testing purposes.

3.6.2.2.2 Training for Trainers. The contractor shall provide formal training to government personnel that will be in charge of training later on. Contractor personnel will also be available to attend the first set of training sessions to provide feedback to trainers.

3.7 PRECEDENCE

a) The order of precedence of requirements shall be, in turn, this specification, the Interface Specifications (IFSs), Segment Specifications, hardware and software configuration item (CI) specifications, Interface Control Documents (ICDs), and system test plan.

b) In case of conflict between the parameters derived in 3.2.3.1.1 and 3.2.3.1.2, the values in 3.2.3.1.1 and subparagraphs thereto shall have precedence.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 GENERAL

This section establishes the quality assurance methodologies employed to ensure that the RRS has satisfied all contractual requirements. The assurance of successful operation shall be verified and validated by the performance of a test program consisting of the verification and validation processes defined below.

a) Validation Process. The validation process ensures that each successive level of specification is consistent with the parent level. The validation process ensures that the development specifications are consistent with Section 3, and accurately assigns subordinate requirements to the appropriate system segment.

b) Verification Process. The verification process ensures that the HWCIs and CSCIs comply with all requirements as flowed down from this specification, Section 3. The verification process ensures that the product is consistent with the product specification.

4.1.1 Philosophy of Testing

a) A test and evaluation (T&E) program shall be established to provide for HWCI/CSCI requirements verification, system segment verification, RRS qualification, and operational capability verification.

b) This program shall be implemented to verify the overall system, and its hardware and software,conform to the requirements in Section 3.

c) The T&E program shall continue from design and development through final acceptance.

d) Tests and demonstrations of HWCIs/CSCIs shall be accomplished in accordance with the test plans approved by the government.

e) Formal configuration control functions shall be established and implemented by the contractor as required in the Statement of Work.

f) During all formal tests, if a test is terminated because of a failure of either the item under test or test equipment, the test shall be repeated from the beginning after either the test equipment has been restored to certified operation or the failed test item has been restored to operation.

g) During all formal tests, if a failure of a test item does not preclude continuing the test, the test shall be completed and the malfunction noted.

h) After test item repair or reconstruction, either the test shall be repeated from the beginning, or the item shall be tested using a government-approved subset of the original test in order to establish validity of the original test results.

i) Every effort will be made to minimize the impact of testing on the program schedule and cost. To implement this, testing will be accomplished at the lowest development level feasible, and the results of those tests will be used to support/mitigate higher level testing.

4.1.1.1 Development Test Phase. The development test phase consists of contractor-controlled tests used during the development of the HWCIs and CSCIs. No HWCI or CSCI requirements are formally verified during this phase. This phase encompasses the Level 0 testing described hereinafter. The government involvement is informal.

4.1.1.2 Preliminary Qualification Phase

a) Tests undertaken during this phase shall be defined and incrementally accomplished between Critical Design Review (CDR) and the Formal Qualification Test (FQT) period in accordance with a scheduled test program.

b) These tests shall be performed following contractor-developed test plans and procedures and shall be witnessed by contractor's quality assurance personnel.

c) Test results shall be reported during technical meetings to demonstrate contractor progress. This phase encompasses Level 1 tests, as outlined below. The government involvement is informal.

d) Normally, no formal verification of requirements is performed during this phase. However, in those

limited instances where a higher level of integration may preclude access to test points or input/output results, formal verification of HWCI/CSCI requirements may be permitted subject to government approval.

4.1.1.3 Formal HWCI/CSCI Qualification Phase. Tests performed during this phase are those Level 2 tests, as outlined below. These tests are complete and comprehensive tests of the HWCIs/CSCIs prior to HWCI/CSCI integration and provide formal qualification of each HWCI and CSCI. Some specification requirements may be verified during this phase. All tests shall be conducted in accordance with government-approved test plans. The government will witness these tests.

4.1.1.4 System Qualification Phase

a) The majority of the RRS qualification shall be performed during this phase at the contractor's facility in accordance with a government-approved test plan. This includes testing and demonstrating the completed segment at system level in as near an operational configuration and environment as practical.

b) The final portion of this test phase shall consist of a pre-installation system demonstration to verify system operation and pertinent interfaces. The government will witness these tests.

4.1.1.5 System Integration Test Phase

a) All of the requirements remaining to be verified shall be accomplished during this test phase and shall be performed at the site. The government will direct the administration of all testing and will interface with other government agencies, as required, to conduct tests.

b) The contractor shall maintain identified RRS elements and shall support the government by developing a test plan for government approval, developing test procedures, conducting the tests, and assisting in evaluating test results.

4.1.1.6 Baseline/Performance Verification Test Phase

a) Operational baseline tests shall be conducted on all equipment currently installed which is to be retained, whether relocated or not, in order to establish operational and performance characteristics prior to any equipment removal or installation.

b) Subsequent to installation and checkout of RRS equipment and any relocation of retained equipment, a second series of identical tests shall be performed on the retained equipment to demonstrate that the operational and performance characteristics have not degraded from the baseline test results.

c) The contractor shall prepare the test plans and procedures for government approval, shall support the conduct of these tests, and shall also provide data reduction, analysis, and test reports. These tests will be witnessed by the government.

d) The contractor shall be responsible for correcting any degraded characteristics.

4.1.1.7 OT&E Phase. OT&E will be conducted by the government in order to determine operational effectiveness and suitability assessments of RRS performance. The contractor shall provide assistance as required.

4.1.1.8 Security Accreditation Phase. If secure commanding is to be used, security accreditation testing shall be conducted by the government in order to determine adequate compliance to security requirements.

4.1.2 Location of Tests

4.1.2.1 Contractor's Location. All tests performed by the contractor to satisfy the required levels of tests, up through formal system qualification and pre-installation demonstration, shall be performed at the contractor's location or any other commercial establishment acceptable to the government.

4.1.2.2 Operational Sites. All tests performed by the contractor as pre-installation baseline tests, post installation performance verification tests, installation and checkout tests, and system performance demonstrations shall be performed at the operational site.

4.1.3 Responsibility for Tests

4.1.3.1 Contractor Responsibilities

4.1.3.1.1 Government Furnished Property Verification. The contractor shall verify the applicability, proper installation, and functionality of GFP.

4.1.3.1.2 Contractor Furnished Property (CFP) Qualification. The contractor shall be responsible for evidence of qualification CFP.

4.1.3.1.3 Test Plan and Procedures. The contractor shall be responsible for developing all test plan and test procedures.

4.1.3.1.4 Verifying Requirements. The contractor shall be responsible for verifying all requirements, either through test, analysis, or demonstration.

4.1.3.1.5 Qualification Tests. The contractor shall perform all qualification tests.

4.1.3.1.6 OT&E Support. During OT&E, the contractor shall provide advice, assistance, and test planning support to government test representatives.

4.1.3.2 Government Responsibilities

4.1.3.2.1 Test Plan Approval. The government will be responsible for approving the test plan and test procedures.

4.1.3.2.2 Witnessing Tests. The government reserves the right to witness any or all formal and informal tests and inspections performed by the contractor.

4.1.3.2.3 Conduct OT&E Formal Tests. The government will conduct all OT&E formal tests, with contractor assistance.

4.1.3.2.4 Conduct Security Accreditation Tests. The government will conduct all security accreditation tests, with contractor assistance.

4.1.4 Qualification Methods

4.1.4.1 Inspection Definition. Verification by visual examination of the item, review of descriptive documentation, and comparison of appropriate characteristics with a reference standard to determine conformance to requirements. This includes mechanical inspection of equipment, verification of accuracy and completeness of documentation, database structure and capacity, and CSCI source code audits.

4.1.4.2 Analysis Definition. Verification by evaluation or simulation using mathematical representations, charts, graphs, circuit diagrams, or data reduction. This includes analysis of algorithms independent of computer implementation, analytical conclusions drawn from test data, and extension of test-produced data to untested conditions.

4.1.4.3 Demonstration Definition. Verification by operation, movement, or adjustment of the item under a specific condition to perform the designed function. This includes content and accuracy of displays, comparison of system products with independently derived test cases, and prompt system recovery from induced failure conditions.

4.1.4.4 Test Definition. Verification through systematic exercising of the applicable item under all appropriate conditions with instrumentation and collection, analysis, and evaluation of quantitative data. This includes electrical continuity, proper operating voltages, current grounding, resistance to electromagnetic interference, correct Computer Software Component (CSC) control, and correct CSC data flow.

4.1.5 Test Levels

4.1.5.1 Development Level Tests. These tests are contractor controlled and are used to support the design and development of HWCIs and CSCIs. The government reserves the right to participate in these tests.

4.1.5.1.1 Hardware Level 0. These tests shall be used to support the design and development of key component and/or interface requirements and include the tests below.

4.1.5.1.1.1 Compatibility Tests. Component, circuit, breadboard, brassboard, and internal and external interface compatibility tests.

4.1.5.1.1.2 Parts Certification Tests. Parts certification tests performed on samples of a parts lot to

determine whether or not that lot of parts can be certified as meeting the requirements of this specification.

4.1.5.1.1.3 Development Verification Tests. Development and verification test and inspections which ensure that the component items, when tested, will meet the equipment requirements specified in Section 3.

4.1.5.1.2 Software Level 0. The objective of Level 0 qualification is to validate the functional units. Each unit shall compile or assemble successfully and shall have successively completed a design and code walk-through. Level 0 tests shall be used to verify proper control and data flow, numerical results, stability, convergence, scaling and range, etc. Each unit shall be validated by executing all program statements and verifying that all outputs and control decisions are in accordance with unit level specifications.

4.1.5.2 Preliminary Qualification Level Tests. These tests shall be used to support the design and development of HWCIs and CSCIs.

4.1.5.2.1 Hardware Level 1. The objective of Level 1 testing is to verify the performance of LRUs. The test shall verify the correct functional performance, interfaces, and the hardware control and status performance. Test fixtures and generators shall be used to demonstrate functional performance and the correct response to control signals.

4.1.5.2.2 Software Level 1. The objective of Level 1 testing is to validate CSCs. Level 1 tests shall verify inter-unit communications, control, and parameter passing. Pre-planned test cases shall be used to provide standards against which results are to be evaluated.

4.1.5.3 Formal HWCI/CSCI Qualification Level Tests. HWCIs and CSCIs shall be qualified at this level. Test shall be conducted by the contractor according to test plans approved by the government. The government will witness these tests.

4.1.5.3.1 Level 2 HWCI Design Qualification. The objective of Level 2 testing is to validate HWCIs. Level 2 tests shall verify that the sum of LRUs and components which comprise the HWCI satisfy the requirements allocated to the applicable product specification. These tests shall be performed prior to integration of HWCI and CSCI components.

4.1.5.3.2 Level 2 CSCI Design Qualification. The objective of Level 2 testing is to validate each CSCI. Level 2 testing shall verify inter-CSC communications, control, and parameter passing. Pre-planned test cases shall be used to provide standards against which results are to be validated.

4.1.5.3.3 Level 2 HWCI/CSCI Integration Qualification. The objective of this testing is to demonstrate that the integrated HWCI and applicable CSCI perform to those requirements not previously verified during other Level 2 tests.

4.1.5.4 Formal System Qualification Tests. Formal system qualification test shall be performed to verify compliance to the requirements in Section 3 of this specification. These formal tests involve processing of real data only in cases where real data cannot be obtained will the use of simulated data be allowed. These tests shall also validate all software components, including the verification of inter-CSCI and CSCI-to-HWCI communications, control, and parameter passing.

4.1.5.5 Installation/Integration Level Tests. Installation and integration tests shall be performed at each site where equipment is installed.

4.2 FORMAL TESTS

a) Formal tests shall include all tests, inspections, analyses, and demonstrations which are required to verify that the RRS as designed, developed, built, integrated, and installed, meets the requirements of this procurement.

b) All formal tests shall be witnessed and verified by the government.

4.2.1 Configuration Test Items

a) Formal tests shall be conducted to verify all specified requirements for each configuration item (CI) in accordance with test plans approved by the government.

b) These tests shall include verification of all requirements allocated to each CI by this specification or by other CIs, as well as tests to verify the remaining requirements specified in each CI development specification which are not allocated from this specification or from another CI.

4.2.2 System Qualification Tests

a) Formal tests shall be conducted to verify all specified requirements in accordance with approved test plans.

b) All interfaces with external systems shall be tested and verified during these tests.

c) The final test shall consist of pre-installation system demonstration to verify system operation and external interfaces.

4.2.3 Transportation and Handling

a) At the completion of qualification testing at the contractor's facility, the components shall be shipped

to the pertinent sites in accordance with contractual delivery schedules.

b) Upon arrival, key physical and environmental requirements shall be reverified.

4.2.4 System Installation/Integration Tests

a) A phased build-up system test shall be performed at each site.

b) The test plan shall identify the requirements which must be verified by each type of interface.

c) All requirements not verified during qualification testing at the contractor's facility shall be verified during this test and demonstration at each site for each system configuration.

d) All external interfaces shall be verified.

4.2.5 Analyses

a) Individual analyses for those performance parameters and requirements which cannot be completely or readily verified through testing and inspection techniques shall be performed subject to government approval.

b) The data used in the analyses shall include test data measured during a test on the complete item or components of the item.

c) Existing design/test data, use-history data, and derived analytical data shall also be used in the analyses.

d) Analyses should be completed at the HWCI/CSCI and system levels as applicable. These analyses will be subject to government review and approval.

4.2.6 Baseline/Performance Verification Test. Prior to and subsequent to equipment installation, a series of demonstrations and tests shall be performed at each site. Results of both series of tests will be compared by analysis to verify any performance degradation and/or improvement resulting from the installation.

4.2.7 Data Security. The requirements below apply if secure commanding is to be used.

a) Tests shall be performed to verify that the functions which control or deny access to the system fulfills system access security requirements.

b) Recovery of the system to a secure state shall be demonstrated by inducing failures and rerunning test cases after invoking the standard restart and recovery functions.

c) Positive control of data distribution from the RRS to other systems shall be verified by exercising all logical paths for information release.

4.2.8 OT&E. The government will conduct these tests. The contractor shall provide assistance, as requested, for test plans and procedures development, testing support, and test evaluation support.

4.2.9 Inspections

4.2.9.1 Hardware and Documentation Inspections

a) Inspections of parts, materials, CIs, drawings, reports, and specifications shall be conducted.

b) During the qualification testing, the contractor shall conduct a walk-through inspection of the system in its operational configuration.

c) Discrepancies shall be noted and corrected prior to shipment of the system.

4.2.9.2 Software and Documentation Inspections

4.2.9.2.1 Prior to Software Development. Prior to software development, the government will review the entire original design and associated documentation.

4.2.9.2.2 During Software Development. During software development, the government will spot-check contractor

compliance to the requirements in 3.3.8.3, 3.3.8.4, and subparagraphs thereto.

4.2.9.2.3 Government Review. Upon the contractor's completion of all code and documentation inspection following successful CI testing, the government will review the entire code and associated programming documentation.

4.2.9.2.4 Contractor Assistance. The contractor shall provide assistance in these reviews by organizing all pertinent material into a consistent and complete annotated sequence.

4.2.9.3 Safety Inspection

a) Safety verification shall be performed by a combination of analysis and inspection.

b) A safety inspection shall be performed for verification of those safety requirements which can be most effectively verified in this manner with government concurrence.

c) The inspection shall consist of a walk-through verification against a government-provided safety checklist.

4.2.10 Interface Demonstration. Demonstrations of interfaces shall be performed at the installation sites during system integration tests by connecting to data sources, power sources, and external interface system elements.

4.2.11 Interchangeability Analysis. The contractor shall use sample hardware elements to verify through analysis and demonstration that the interchangeability requirements are met.

4.2.12 Software Maintenance

a) A record of all software change actions taken at the contractor's facility shall be maintained during qualification testing.

b) All changes, including errors and non-errors, shall be recorded with the method of change.

4.3 FORMAL TEST CONSTRAINTS

4.3.1 Site Downtime

a) The contractor shall provide test plan and procedures which minimizes site downtime and ongoing operations.

b) If significant impacts to site operations are expected, use of alternate resources providing functional performance verification shall be used.

4.3.2 Use of Simulators

4.3.2.1 Contractor Simulators. The contractor shall identify all CFP simulators to be used in critical test tasks.

4.3.2.2 Government Simulators. The government will identify in the Request for Proposal (RFP) the simulators available to the offerers. The information identifying the simulators the offeror proposes to use will be placed on contract.

4.4 QUALIFICATION CROSS REFERENCE

4.4.1 Requirements Test Matrix. The contractor shall develop, and deliver, a requirements test matrix that will detail proof methodology for all contractual/technical requirements. This matrix shall be used to review test plans, test procedures, and other test checklists developed by the contractor.

4.4.2 Requirements Verification Matrix (RVM). The government will request in the RFP that the offeror provide an RVM accompanying proposed test verification program. The RVM shall correlate the requirements in Section 3 to the HWCIs and CSCIs being proposed.

5.0 PREPARATIONS FOR DELIVERY

Preparations for delivery shall be as detailed in contractual provisions.

6.0 NOTES

6.1 ACRONYMS/ABBREVIATIONS

ARC	Ames Research Center
AVCL	Animal Compartment Ventilation Loop
BIT	Built-In-Test
BITE	Built-In Test Equipment
BTU	British Thermal Unit
C2E	Command and Control Emulator
CDR	Critical Design Review
CFP	Contractor Furnished Property
CG	Center of Gravity
CI	Configuration Item
CIL	Configuration Identification List
CONUS	Continental United States
COTS	Commercial OTS
CS	Command Subsystem
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CSU	Command Support Unit
db	Decibel
DHU	Data Handling Unit
DM	Deployed Module
DRM	Design Reference Mission

EBM	ESA Botany Module
ECLSS	Environmental Control/Life Support System
ELV	Expendable Launch Vehicle
EM	Experiment Module
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
ESA	European Space Agency
ESM	Silicon Elastomer
ETR	Eastern Test Range
FMEA	Failure Modes & Effects Analysis
FQT	Formal Qualification Test
GBM	General Biology Module
GCEM	Ground Control Experiment Module
GFI	Government Furnished Information
GFP	Government Furnished Property
GFR	Government Furnished Resources
GFS	Government Furnished Software
GIDEP	Government/Industry Data Exchange Program
GLP	Government Loaned Property
GNC	Guidance, Navigation, and Control
GPS	Global Positioning System
GSE	Ground Support Equipment
GTM	Ground Test Module
HOL	High Order Language
HWCI	Hardware Configuration Item
ICD	Interface Control Document
IFS	Interface Specification
IMU	Inertial Measurement Unit
LCC	Life Cycle Cost
LRU	Line Replaceable Unit
LSA	Logistic Support Analysis
lux	Illuminance (1 Lumen/Square Meter)
MM	Main Module
Mmax	Maximum Corrective Maintenance Time
MS	Margin of Safety

MS	Mission Support
MTBCF	Mission Time Between Critical Failures
MTBDE	Mean Time Between Downing Events
MTBMA	Mean Time Between Maintenance Actions
MTBR	Mean Time Between Removals
MTTR	Mean Time to Repair
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NTADN	NASA Tracking and Data Network
OBP	On-Board Processor
OS	Operating System
OT&E	Operational Test and Evaluation
OTS	Off-the Shelf
OTSI	Off-the-Shelf Item
PA	Payload Adaptor
PCM	Pulse Code Modulator
PI	Principal Investigator
PM	Payload Module
PME	Payload Module Emulator
ppd	Pounds Per Day
ppm	Parts Per Million
PSE	Peculiar Support Equipment
PTP	Power Thermal Pack
RDI	RRS Developed Item
RF	Radio Frequency
RFI	Radio Frequency Interference
RFP	Request For Proposal
RM	Rodent Module
RPM	Revolutions Per Minute
RRS	Reusable Reentry Satellite
RRV	Reusable Reentry Vehicle
RVM	Requirements Verification Matrix
S/C	Spacecraft
SM	Support Module
SOH	State of Health

SPF	Single Point Failure
SRU	Shop Replaceable Unit
SSOH	Stored State of Health
T&E	Test and Evaluation
TBD	To Be Determined
TBS	To Be Specified
TDRSS	Tracking and Data Relay Satellite System
TT&C	Tracking, Telemetry, and Command
V&V	Verification and Validation
VC&C	Vehicle Command and Control
Vdc	Volts, Direct Current
VE	Vehicle Emulator
WTR	Western Test Range

6.2 REFERENCE DOCUMENTS

TM-78119 P

NASA Technical Memorandum , "Space and Planetary Environment Criteria Guidelines for Use in Space Vehicle Development, 1982 Revision."

TM-82473 P

NASA Technical Memorandum , "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1982 Revision."

TM-101043 P

NASA Technical Memorandum "A Conceptual Design Study of the October 1988 Reusable Reentry Satellite," NASA Ames Research Center

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Environment and Special Senses, In: Methods of Animal Experimentation, Vol IV, W.I. Gay, ed., Academic Press, 1973.

---- P
ESA Botany Module Specification

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Federation of American Societies for Experimental Biology (FASEB) Biological Handbooks.

---- P
General Biology Module Specification

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Housing to Control Research Variables, In: The Laboratory Rat, Vol I, H.J. Baker et al., eds., Academic Press, 1973.

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ADDENDUM A. Ground Control Experiment Module (GCEM)

A.1.0 SCOPE

This specification establishes the performance, design, development, and test requirements for the GCEM, a subsystem of the Reusable Reentry Satellite system.

A.2.0 APPLICABLE DOCUMENTS

As specified in RRS-SS-100, Section 2.

A.3.0 REQUIREMENTS

A.3.1 System Definition. The RRS System is designed to provide a pseudo-gravitational environment, of varying degrees, for the performance of user-determined experiments. This environment, created by controlling spacecraft attitude rotation, develops a simulated gravitational effect, and can be varied by controlling the spacecraft spin rate.

The RRS satellite consists of a Reusable Reentry Vehicle (RRV) and a mission-unique payload. It also includes an expandable infrastructure that allows compact launch and recovery capabilities, and upon on-orbit deployment, extends the payload module through the use of 100 foot deployable masts, and generates artificial gravity by centripetal acceleration.

The GCEM will permit the user to collect experiment baseline data, and determine the differences generated by the gravity variable.

A.3.1.1 GCEM General Description. The GCEM consists of two elements:

a) The Ground Test Module (GTM) is a non-flight version of the generic Payload Module, and is used to generate experiment control and reporting data. The GTM outputs ground test data to the Vehicle Emulator (VE), and accepts commands via the VE to run ground control experiments.

b) The Vehicle Emulator emulates the RRV Main Module, providing identical interface support to the PM, and relaying ground experiment data to the Peculiar Support Equipment (PSE). The VE accepts test data from the GTM and transfers it to support equipments, and relays external commanding from the PSE to the GTM.

A.3.1.2 Mission. The GCEM is designed to provide an experiment control environment mimicking the on-orbit environment, with the exception of the microgravity or fractional gravity variable. Due to the unique design of the RRS that allows the gravity field to always be applied on a vector from the top to the bottom of the payload, simulation of on-orbit conditions can be accomplished by simply placing the GTM in the VE, and operating it under normal Earth gravity conditions.

A.3.1.2.1 Ground Testing. Ground testing, including brassboard system development and design verification testing, pre-production design and production verification testing, production acceptance testing, pre-launch verification testing, post-flight system diagnostic testing, and refurbishment testing shall be required for the RM and the installed system elements.

A.3.1.2.2 Delayed Mission Simulation

a) The GCEM shall operate to duplicate the precise controllable conditions imposed upon the orbiting test specimens, but delayed in time by a fixed interval to the extent that those conditions may be duplicated on the ground.

b) Exceptions shall be variable gravity and radiation, as well as as any as-yet undetected differences.

A.3.1.2.3 Flight Control Tests

a) The full sequence of on-board RM in-flight control program functions shall be verified and validated after initial design and before each RRS flight.

b) Correct responses and timeliness of responses shall be verified and documented.

A.3.1.2.4 Vivarium Tests

a) Because of the sensitivity of living experiment specimens to trace contaminants, and to assure that only the desired space-peculiar variables are affecting the experiment, live testing of the flight test specimens shall be conducted in the GCEM as a method of validating the specimen support facilities.

b) The vivarium tests shall be conducted with system conditions as near to identical to flight conditions as possible.

c) The same consumables (if practical, from the same batch where that is a factor) shall be provided in the pre-flight vivarium tests as shall be used in flight.

d) Careful records shall be kept of all materials and processes used, and of any anomalies detected during or after the tests.

A.3.2 Characteristics

A.3.2.1 GTM Characteristics. In order to maintain experiment control integrity, it is essential that the GTM retain all characteristics assigned to the Payload Module, as defined in Specification RRS-PS-200.

A.3.2.2 VE Characteristics. Specific VE characteristics and capabilities are delineated in Specification RRS-RRV-200.

A.3.3 Design and Construction

A.3.3.1 Ground Test Module. It is envisioned that a non-flight qualified version of the Payload Module will be utilized.

As such, all Payload Module design and construction requirements will be levied against the GTM. Specific requirements are delineated in Specification RRS-PS-200.

A.3.3.2 Vehicle Emulator. The Vehicle Emulator used in the GCEM will be designed and constructed in accordance with those requirements levied in Specification RRS-RRV-200, Addendum A.

A.3.4 Documentation. As specified in Specification RRS-SS-100, para 3.4 and associated subparagraphs.

A.3.5 Logistics. As specified in Specification RRS-SS-100, para 3.5 and associated subparagraphs.

A.3.6 Personnel and Training. As specified in Specification RRS-SS-100, para 3.6 and associated subparagraphs.

A.3.7 Functional Area Characteristics. As specified in Specification RRS-SS-100, para 3.7 and associated subparagraphs.

A.3.8 Precedence. As specified in Specification RRS-SS-100, para 3.8 and associated subparagraphs.

A.4.0 QUALITY ASSURANCE PROVISIONS

As specified in Specification RRS-SS-100, para 4.0 and associated subparagraphs.

A.5.0 PREPARATION FOR DELIVERY

As specified in Specification RRS-SS-100, para 5.0 and associated subparagraphs.